WHAT IS CLAIMED IS:

1. A method of manufacturing an optical filter by determining when deposition of a layer of the optical filter is to terminate, the method comprising:

calculating, with a data processor, a theoretical transmission T_i of light through the layer;

calculating, with the data processor, an expected deposition time t_i of the layer,

measuring, during deposition of the layer for a period less than t_i, a measured transmission T_m of light through the layer;

determining, with the data processor, when deposition of the layer is to terminate based upon the theoretical transmission T_i and the measured transmission T_m.

2. The method of Claim 1 wherein t_i is calculated based upon a desired thickness of the layer d and a known deposition rate r for the layer.

3. The method of Claim 1,

wherein calculating T_i calculates T_i based upon a desired thickness d of the layer at a series of wavelengths, thereby generating a series of curves T_i vs. d at each of the series of wavelengths,

wherein measuring T_m measures T_m as a function of actual time transpired t, thereby generating a curve T_m vs. t, and

wherein the method further comprises:

determining an optical monitoring wavelength λ_m based upon the series of curves T_i vs. d, thereby selecting a single curve T_i vs. d at λ_m from the series of curves,

wherein determining when deposition of the layer is to terminate comprises:

generating a plurality of transmission data curves T_{ijk} as a function of multiple time values based upon the single curve T_i vs. d at λ_m;

calculating error between each T_{ijk} curve and the curve T_m vs. t;

selecting one of the plurality of T_{ijk} curves having a minimum calculated error, the selected T_{ijk} curve being associated with one of the multiple time values; and

determining when deposition of the layer is to terminate based upon the one of the multiple time values.

4. The method of Claim 3 wherein generating the plurality of transmission data curves T_{ijk} generates the curves T_{ijk} by plotting values of T_i against a two-dimensional array of time vectors.

5. The method of Claim 3 wherein the plurality of transmission data curves T_{ijk} are scaled prior to calculating error between each T_{ijk} curve and the curve T_m vs. t.

6. The method of Claim 5,

wherein if the curve T_i vs. d at λ_m has more than one extremum, (1) a mid-point between two extrema for each curve T_{ijk} is scaled by a factor so that it equals a mid-point between two extrema of the curve T_m vs. t, and (2) maximum and minimum values on each curve T_{ijk} are scaled by scaling uniformly about a mean of the T_{ijk} curve being scaled so that a difference between the maximum and minimum values for each curve T_{ijk} is equal to that of the curve T_m vs. t, and

wherein if the curve T_i vs. d at λ_m does not have more than one extremum, the mean of each curve T_{ijk} is scaled by a uniform factor so that the mean of each curve T_{ijk} is equal to a mean of the measured curve T_m vs. t.

7. The method of Claim 3 wherein the optical filter is a long-wave-pass optical edge filter.

8. The method of Claim 1,

wherein calculating T_i calculates T_i based upon a desired thickness d of the layer at a series of wavelengths, thereby generating a series of curves T_i vs. d at each of the series of wavelengths,

wherein measuring T_m measures T_m as a function of actual time transpired t, thereby generating a curve T_m vs. t, and

wherein the method further comprises:

determining an optical monitoring wavelength λ_m based upon the series of curves T_i vs. d, thereby selecting a single curve T_i vs. d at λ_m from the series of curves; and

converting the single curve T_i vs. d at λ_m to T_i vs. t using the equation $t = d/r$, where r is a known deposition rate for the layer,

wherein determining when deposition of the layer is to terminate comprises:

calculating a deposition rate r_{ci} by minimizing an error between the curve T_i vs. t and the curve T_m vs. t, the minimizing occurring by varying parameters pertaining to the curve T_i vs. t; and

determining when deposition of the layer is to terminate based upon the calculated deposition rate r_{ci} or a deposition rate derived therefrom.

9. The method of Claim 8,

wherein the layer is a current layer,

wherein the parameters are β_1, β_2, β_3, and the deposition rate r, and

wherein β_1, β_2, and β_3, are defined as:

$$\beta_1 = \frac{n_a^2 + n_{m+1}^2}{2}\left(|p|^2 + \frac{|q|^2}{n_{m+1}^2}\right) + 2n_a \operatorname{Re}(pq^*),$$

$$\beta_2 = \frac{n_a^2 - n_{m+1}^2}{2}\left(|p|^2 - \frac{|q|^2}{n_{m+1}^2}\right), \text{ and}$$

$$\beta_3 = \left(\frac{n_a^2}{n_{m+1}} - n_{m+1}\right)\operatorname{Im}\left(p^* q\right),$$

where n_a is a refractive index of an incident medium, n_{m+1} is a refractive index of the layer, and p and q are defined as:

$$\begin{bmatrix} p \\ q \end{bmatrix} = \prod_{l=1}^{m} \begin{bmatrix} \cos\theta_l & -i\sin\theta_l / n_l \\ -in_l \sin\theta_l & \cos\theta_l \end{bmatrix} \begin{bmatrix} 1 \\ n_s \end{bmatrix}$$

where θ_l is accumulated phase in an l_{th} layer of the optical filter, m represents a number of layers that have been deposited, n_l is a refractive index of the l_{th} layer, n_s is a refractive index of a substrate, and $i = \sqrt{-1}$ in the definition of p and q.

10. The method of Claim 8 further comprising:

calculating a best deposition rate r_{bi} by calculating a rolling average of other r_{ci} deposition rates,

wherein determining when deposition of the layer is to terminate determines when deposition of the layer is to terminate based upon the best deposition rate r_{bi}.

11. The method of Claim 8 wherein the optical filter is a short-wave-pass optical edge filter.

12. A method of making an optical filter using an apparatus, the filter designed to have N layers and the method comprising:

calculating, with a data processor, theoretical transmission data for each layer;

determining, with the data processor, which of the N layers are to be optically monitored;

calculating an expected deposition time for a current layer being deposited based upon a designed thickness of the layer and a deposition rate of the apparatus for the layer, the current layer being one of the N layers;

measuring, during deposition of the current layer for a time less than the expected deposition time, measured transmission data for the current layer, if the current layer is determined to be an optically monitored layer;

determining, with the data processor, when deposition of the current layer is to terminate based upon the theoretical transmission data and the measured transmission data, if the current layer is determined to be an optically monitored layer;

determining, with the data processor, when deposition of the current layer is to terminate based upon expiration of the expected deposition duration, if the current layer is not determined to be an optically monitored layer.

13. The method of Claim 12 wherein determining which of the N layers are to be optically monitored comprises:

adding noise to the theoretical transmission data, thereby generating estimated actual transmission data;

simulating deposition of the N layers using the theoretical transmission data and the estimated actual transmission data, the simulating producing a simulated thickness for each layer;

calculating an error between the simulated thickness and the designed thickness for each layer;

selecting layers that have an error below a threshold as layers to be optically monitored.

14. The method of Claim 13 wherein the optical filter is a long-wave-pass optical edge filter and the threshold is 0.2% error.

15. The method of Claim 13 wherein the optical filter is a short-wave-pass optical edge filter and the threshold is 0.5% error.

16. An optical filter comprising a transparent substrate having a surface and one or more thin layers of material disposed overlying the surface wherein at least one of the layers is formed by the method of Claim 1.

17. The optical filter of Claim 16 wherein the one or more thin layers of material comprise a plurality of alternating layers of materials having respectively different indices of refraction.

18. An optical long-wave-pass filter comprising a transparent substrate having a surface and alternating thin layers of materials having respectively different indices of refraction disposed overlying the surface wherein at least one of the layers is formed by the method of Claim 3.

19. An optical short-wave-pass filter comprising a transparent substrate having a surface and alternating thin layers of materials having respectively different indices of refraction disposed overlying the surface wherein at least one of the layers is formed by the method of Claim 8.

20. An optical edge filter comprising a transparent substrate having a surface and alternating thin layer of materials having respectively different indices of refraction disposed overlying the surface, the materials comprising hard coating materials, and the thicknesses of the layers chosen to produce a filter edge steepness less than about 0.8%, wherein edge steepness is defined as (a) an edge width from a 50% transmission wavelength to an optical density 6 ("OD6") wavelength divided by (b) the 50% transmission wavelength.

21. The optical edge filter of Claim 20 wherein the filter edge steepness is less than about 0.463%.

22. The optical edge filter of Claim 20 wherein the filter average transmission is above about 93%.

23. The optical edge filter of Claim 20 wherein the filter average transmission is above about 95%.

24. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, an optical path coupling light from the sample to an analyzer or viewer, and a filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein the filter is an optical edge filter comprising a layer made by the method of Claim 1.

25. The optical analysis system of Claim 24 wherein the first filter is a long-wave-pass filter or a short-wave-pass filter.

26. The optical analysis system of Claim 24 wherein the second filter is a long-wave-pass filter or a short-wave-pass filter.

27. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, an optical path coupling light from the sample to an analyzer or viewer, and a filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein the filter is an optical edge filter comprising a layer made by the method of Claim 3.

28. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, an optical path coupling light from the sample to an analyzer or viewer, and a filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein the filter is an optical edge filter comprising a layer made by the method of Claim 8.

29. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, an optical path coupling light from the sample to an analyzer or viewer, and a filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein the filter is an optical edge filter made by the method of Claim 12.

30. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, an optical path coupling light from the sample to an analyzer or viewer, and a filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein the filter is an optical edge filter according to Claim 20.

31. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, an optical path coupling light from the sample to an analyzer or viewer, and a filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein the filter is an optical edge filter according to Claim 21.

32. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, an optical path coupling light from the sample to an analyzer or viewer, and a filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein the filter is an optical edge filter according to Claim 22.

33. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, an optical path coupling light from the sample to an analyzer or viewer, and a filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein the filter is an optical edge filter according to Claim 23.

34. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, a first filter in the path between the source and the sample for blocking light at some wavelengths different from the excitation light, an optical path coupling light from the sample to an analyzer or viewer and a second filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein at least the first or the second filter is an optical edge filter comprising a layer made by the method of Claim 1.

35. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, a first filter in the path between the source and the sample for blocking light at some wavelengths different from the excitation light, an optical path coupling light from the sample to an analyzer or viewer and a second filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein at least the first or the second filter is an optical edge filter comprising a layer made by the method of Claim 3.

36. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, a first filter in the path between the source and the sample for blocking light at some wavelengths different from the excitation light, an optical path coupling light from the sample to an analyzer or viewer and a second filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein at least the first or the second filter is an optical edge filter comprising a layer made by the method of Claim 8.

37. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, a first filter in the path between the source and the sample for blocking light at some wavelengths different from the excitation light, an optical path coupling light from the sample to an analyzer or viewer and a second filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein at least the first or the second filter is an optical edge filter made by the method of Claim 12.

38. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, a first filter in the path between the source and the sample for blocking light at some wavelengths different from the excitation light, an optical path coupling light from the sample to an analyzer or viewer and a second filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein at least the first or the second filter is an optical edge filter according to Claim 20.

39. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, a first filter in the path between the source and the sample for blocking light at some wavelengths different from the excitation light, an optical path coupling light from the sample to an analyzer or viewer and a second filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein at least the first or the second filter is an optical edge filter according to Claim 21.

40. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, a first filter in the path between the source and the sample for blocking light at some wavelengths different from the excitation light, an optical path coupling light from the sample to an analyzer or viewer and a second filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein at least the first or the second filter is an optical edge filter according to Claim 22.

41. An optical analysis system for exciting a sample of material with light of a first wavelength to produce a measurable or viewable optical response at a second wavelength different from the first, the system comprising a source of excitation light, an optical path coupling the excitation light to the sample, a first filter in the path between the source and the sample for blocking light at some wavelengths different from the excitation light, an optical path coupling light from the sample to an analyzer or viewer and a second filter in the path between the sample and the analyzer or viewer for blocking some light other than the optical response at the second wavelength,

wherein at least the first or the second filter is an optical edge filter according to Claim 23.